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Determination of Optimal Reserve with Consideration of Variable Generation and Controllable Loads

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FERC Technical Conference
Washington, DC
June 29, 2011

Outline

- Introduction
- Stochastic OPF
- Project Contributions
  - Modeling Enhancements
  - Three Applications
- Project Report

Introduction

Industry Issues

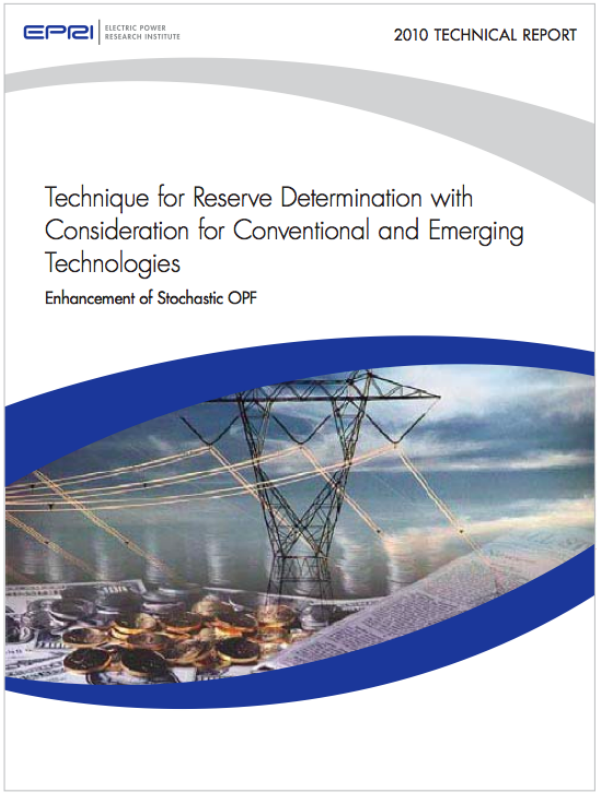
- Reliable dispatch for high levels from variable generation (VG)
- Determining daily/hourly reserve
- Assessing operational risks
- Evaluating reliability under stressful conditions

P173.004 2010 Project Goals

- Examine various risk measures
- Multiple sources of uncertainty
- Ramping needs and constraints
- Application focus

Deliverable

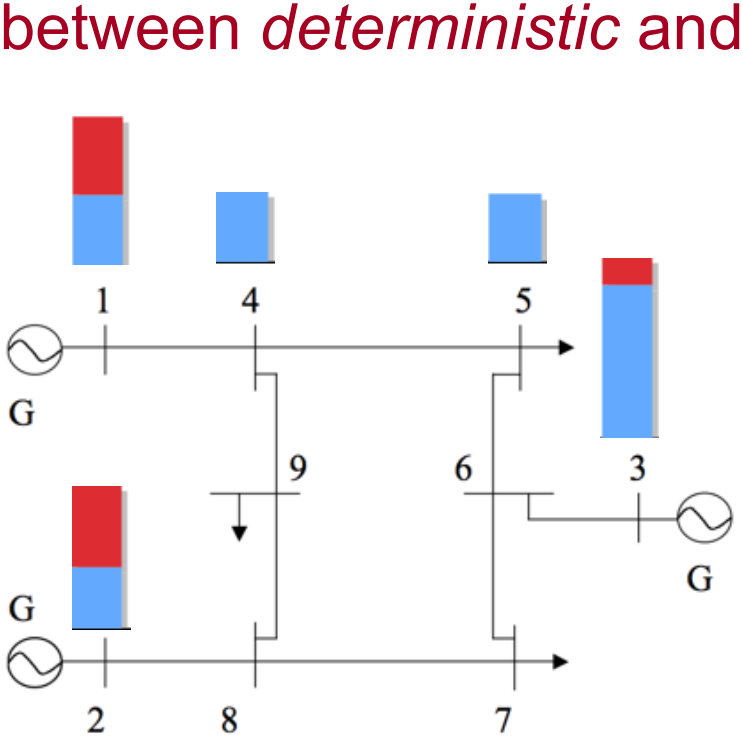
- Technical Report



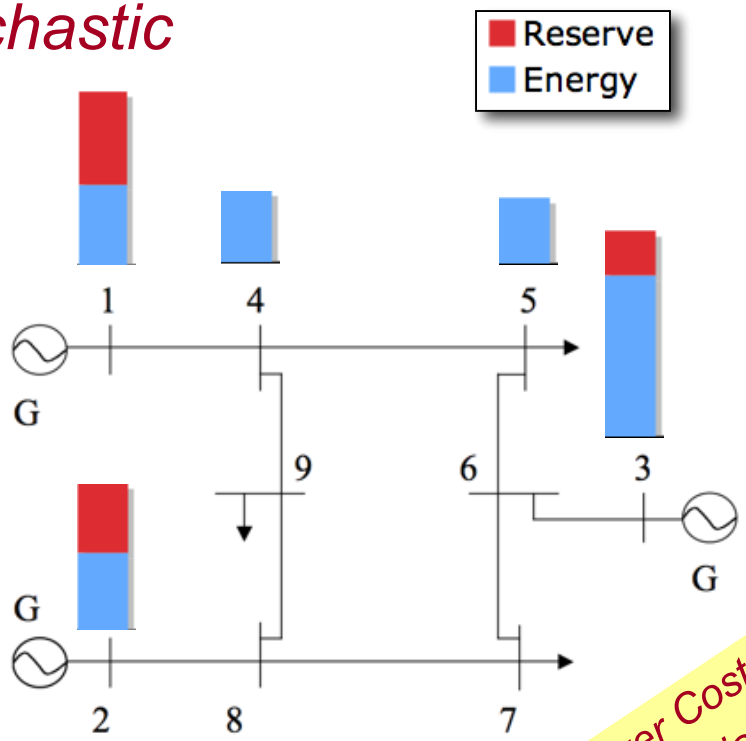
Many Enhancements and Applications

Stochastic OPF

- High wind penetration makes a difference between *deterministic* and *stochastic*



Deterministic
Cost = ~~11026~~ 13793
LOLE = ~~0.134~~ 0.495



Stochastic
Cost = 12599
LOLE = 0.290

Lower Cost
Higher Reliability

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Stochastic OPF

- More energy and reserve
- More diversification

	Energy	Reserve
G1	54.0	56.0
G2	45.0	60.0
G3	110.0	19.0
G4	50.0	0.0
G5	46.0	0.0
Total	*305.0*	*135.0*

Energy	Reserve
60.0	70.4
55.0	50.0
110.0	30.0
50.0	0.0
46.0	0.0
321.0	*150.4*

Wind Variation at G5
20 MW to 60 MW

Stochastic can see variations and risks

Deterministic
Cost = ~~11026~~ 13793
LOLE = ~~0.134~~ 0.495

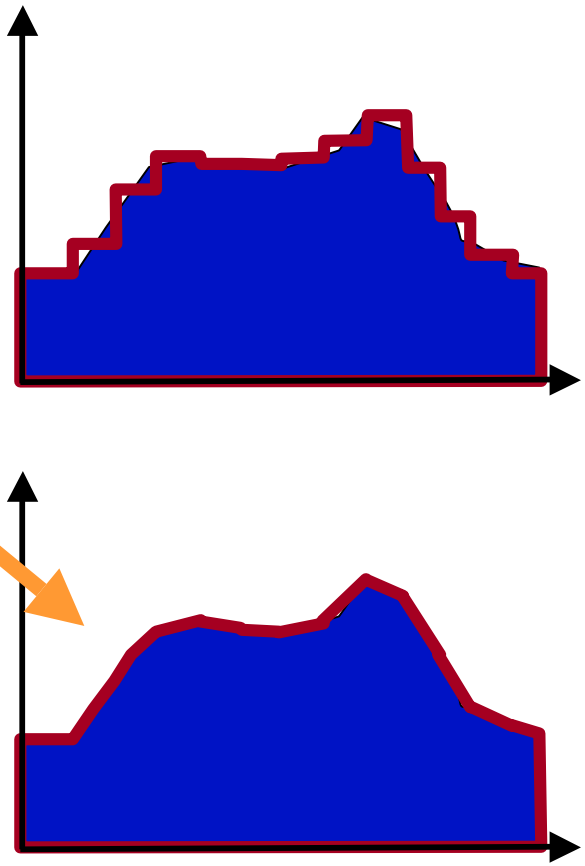
Stochastic
Cost = 12599
LOLE = 0.290

Project Contributions
Model Enhancements

- ✓ **Ramping Scarcity and Allocation**
  - – Ensure smooth, short-term operations
- ✓ **Multiple Sources of Uncertainty**
  - – Better realism
- ✓ **Reporting of Benefits and Risk Measures**
  - – Understand and quantify risks
  - – Establish performance benchmarks

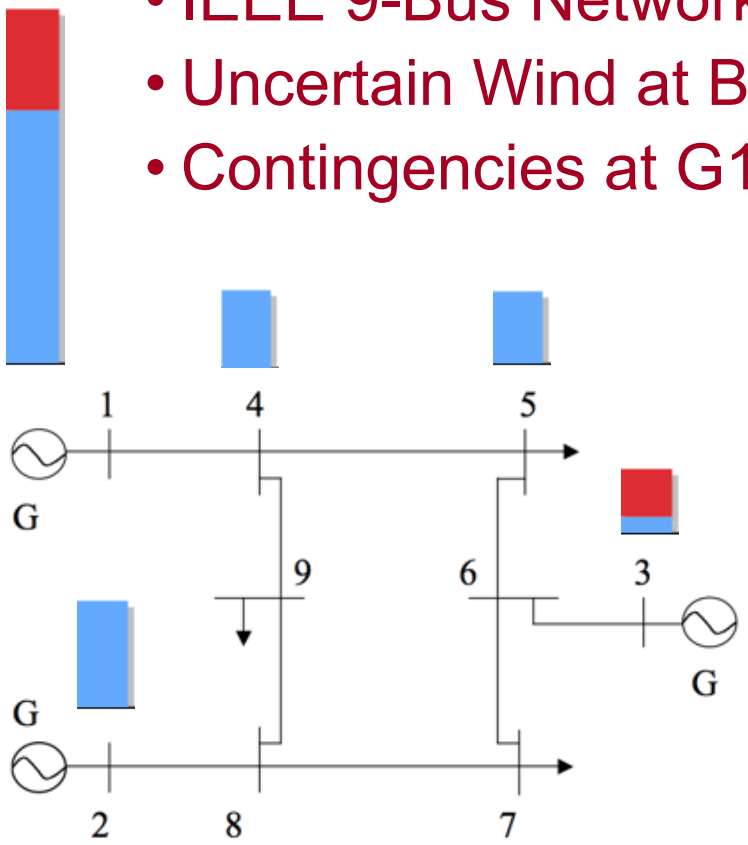
Example Enhancement for Ramping

- ✓ **Ramping Scarcity and Allocation**
  - Share ramp capability between energy ramping and reserve ramping
  - Sub-interval ramping means schedules will ramp
  - Implemented the multiple-stage optimal power flow problem with ramp-rate sharing and sub-interval deviation.

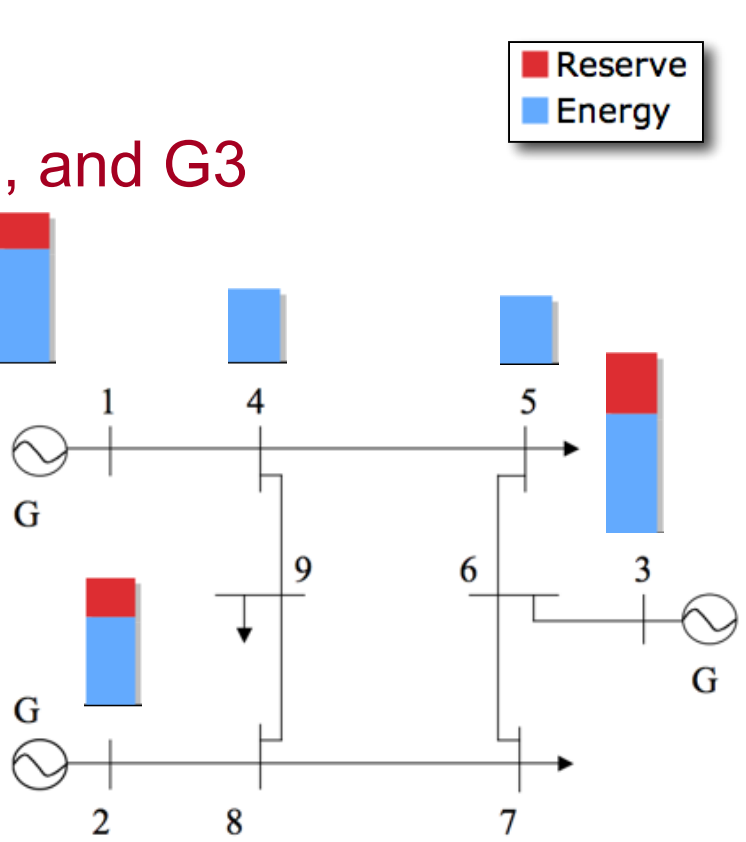


Example Enhancement for Ramping

- IEEE 9-Bus Network
- Uncertain Wind at Bus 5
- Contingencies at G1, G2, and G3



Without Ramping Allocation
Cost = 10448



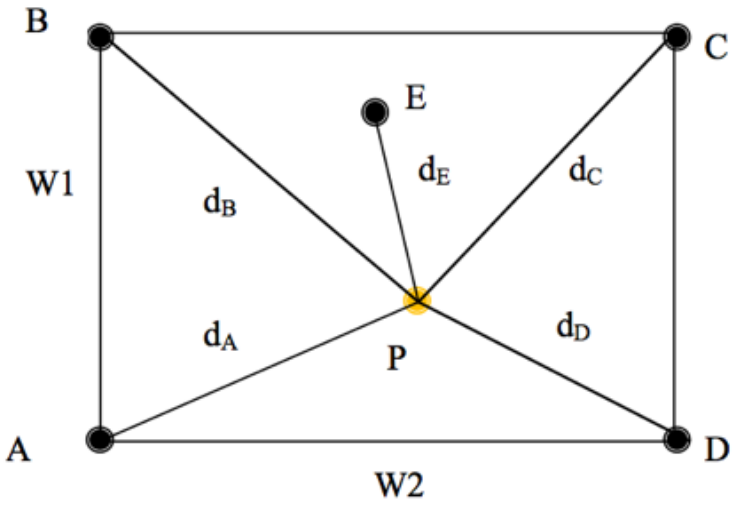
With Ramping Allocation
Cost = 10536

Project Contributions
Three Applications

- ✓ **Reserve Determination Supports Operations Planning**
  - Decide energy and reserve schedules
  - Estimate the expected costs for redispatch
- ✓ **Reserve Validation Supports Operations Planning**
  - *Given energy and reserve schedules*
  - Estimate the expected costs for redispatch
  - Estimate risk levels
- ✓ **Rapid Redispatch Supports System Operations**
  - *Given a sampling of redispatch scenarios*
  - *An actual event takes place*
  - Rapidly compute a optimal or near-optimal re-dispatch

Example Rapid Redispatch

- Precomputed Redispatch Solutions
  - A, B, C, D, E
- Compute New Redispatch
  - P
  - Combination of closest points: A, E, D
- Simple Formulation Allows for Added Features
  - Limit Number and Location of Control Operations

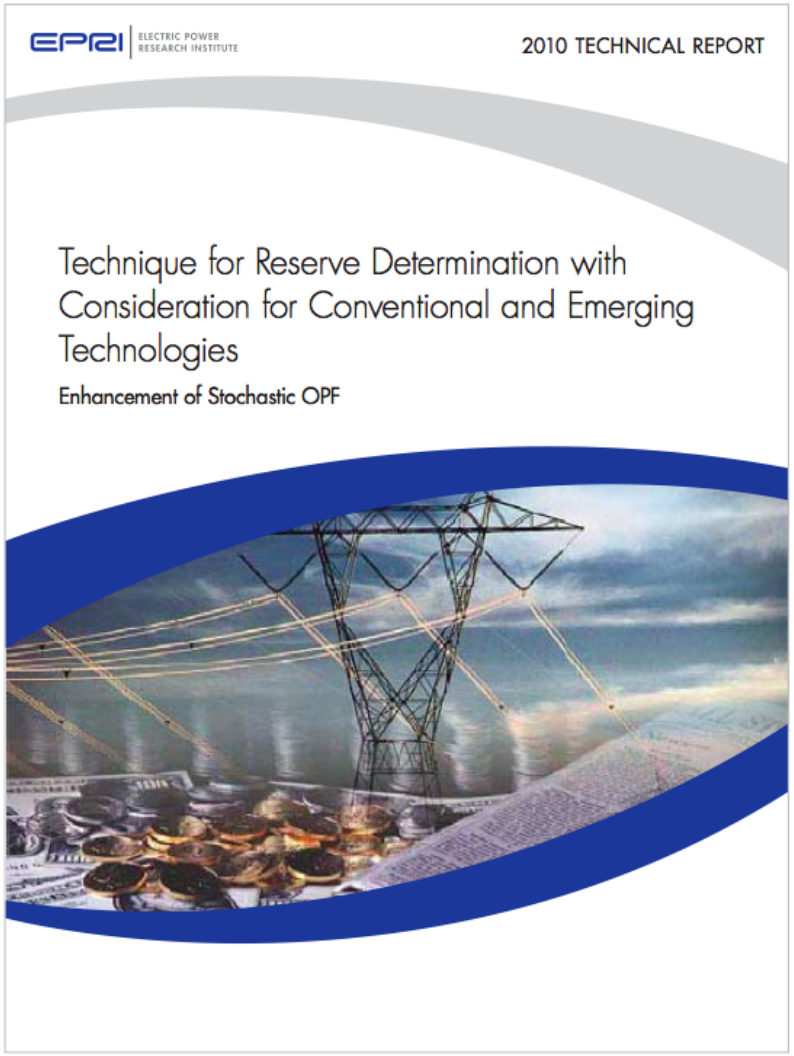


Project Report

Product 1020501

Technique for Reserve Determination with Consideration for Conventional and Emerging Technologies

- Describes all enhancements
- Examples for all applications
- Appendices contain all GAMS code
- *Available now!*



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Questions & Discussion

Together…Shaping the Future of Electricity

Appendix

Enhancement for Risk Measures

- ✓ **Reporting Benefits and Risk Measures**
  - Review of NERC Reliability Metrics Working Group proposals.
  - New estimates for measuring benefits and risk
    - Loss of Load Expectation
    - Expected Unserved Energy
    - System Reserve Margin
    - Duration and Frequency of Outages